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SCIENTIFIC NOTE

A MULTIYEAR SURVEILLANCE FOR *AEDES ALBOPICTUS* WITH BIOGENTS SENTINEL TRAP COUNTS FOR MALES AND SPECIES COMPOSITION OF OTHER MOSQUITO SPECIES

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ABSTRACT. The Biogents Sentinel (BGS) trap is a very effective tool to monitor adult populations of *Aedes albopictus*. We utilized BGS traps during an intensive 5-year surveillance as part of an "Area-wide Management Program for the Asian Tiger Mosquito." During this period, >52,000 mosquitoes were collected, comprising a total of 24 species. The most abundant species was *Ae. albopictus* (54.4%) followed by *Culex* spp. (8.7%), which primarily comprised *Culex pipiens pipiens* (6.5%) and *Cx. restuans* (0.9%). We also collected >15,000 male specimens of *Ae. albopictus* (28.7%) and >3,400 males of *Culex* spp. (6.8%). Other species captured through our surveillance only comprised 1.7% of the total. Although BGS traps are becoming the gold standard instrument for *Ae. albopictus* surveillance, they can also be used to collect other important mosquito species, which can enhance existing vector surveillance programs.

KEY WORDS Biogents Sentinel trap, male mosquitoes, *Culex pipiens pipiens*, *Culex restuans*, New Jersey

The utility of Biogents Sentinel (BGS; Biogents AG, Regensburg, Germany) traps for *Aedes albopictus* (Skuse) surveillance in North America has been gaining popularity in recent years (Farajollahi et al. 2009, Unlu et al. 2011, Crepeau et al. 2013a, Fonseca et al. 2013). Although these traps are very effective tools for *Ae. albopictus* surveillance, they are also expensive and require high maintenance (Crepeau et al. 2013b, Fonseca et al. 2013). As a result, mosquito control programs that have low or recently introduced populations of *Ae. albopictus* within their jurisdictions are hesitant to make an investment in these traps unless they can also be utilized for other purposes. Therefore, a keen interest exists to increase the usefulness of these tools for other species and incorporate the traps into existing vector surveillance programs.

We have been utilizing 40 to 50 BGS traps annually as part of an "Area-wide Management Program for the Asian Tiger Mosquito" during 2008–12 (Unlu et al. 2011, Fonseca et al. 2013). These traps have been primarily used to monitor adult populations of *Ae. albopictus* in urban habitats of Mercer County, NJ, USA. More details about our specific trapping protocols can be found in Unlu et al. (2011) and Fonseca et al. (2013). Briefly, traps were deployed in the field during the active mosquito season continuously for 24 h once per week every year. Each BGS trap was baited with a BG-Lure (Biogents AG), which contains proprietary combinations of ammonia, lactic acid, and fatty acids that are particularly attractive to *Ae. albopictus*. Mosquito surveillance was conducted between July 10 to October 30 in 2008, May 13 to December 2 in 2009, April 30 to November 8 in 2010, April 30 to November 15 in 2011, and May 4 to November 10 in 2012. Mosquitoes were collected in the field, placed on dry ice for transport, and sorted and enumerated in the laboratory using diagnostic keys. Data on male *Ae. albopictus* and *Culex* spp. collected were also recorded and all female specimens of other species were identified to determine mosquito composition and population abundance.

A total of 52,713 mosquitoes were collected over the 5-year study period. The most abundant species was *Ae. albopictus*, totaling 43,779 (83.1%) (Table 1). A total of 28,665 females and 15,114 males of *Ae. albopictus* were collected. The ratio of males to females varied from 1.5:2 to 1:3. The 2nd most abundant group was *Culex* spp., totaling 4,598 (8.7%), which was dominated by *Culex pipiens pipiens* L. (3,418 females, 6.5%) and *Cx. restuans* Theobald (458 females, 0.9%) (Table 1 and Fig. 1). A total of 3,410 (6.4%) *Culex* spp. males were collected. *Aedes japonicus japonicus* (Theobald) collections were minimal, with a total of 350 specimens, with the highest numbers during 2009 (199, 2.1%). The remaining 576 mosquitoes comprised 17 species. Proportion of each species, as well as the total number of each species collected per year, are displayed in Table 1.

Many studies have shown the efficiency of the BGS trap for *Ae. albopictus*, which makes this trap the gold standard trapping method for females of this species (Krockel et al. 2006, Crepeau et al. 2013b). But we have also observed relatively high male counts in our trapping surveillance. High numbers of male collections in mosquito traps

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Table 1. Weekly mosquito counts collected by Biogents Sentinel traps in Mercer County, NJ, during 2008 (14 trap-weeks), 2009 (27 trap-weeks), 2010 (30 trap-weeks), 2011 (41 trap-weeks), and 2012 (25 trap-weeks). Traps were placed for a 24-h collection period once each week.

	Number (%)					
Species	2008	2009	2010	2011	2012	Total
Aedes albopictus females	7,683 (51.1)	5,223 (52.3)	3,195 (43.5)	7,231 (60.0)	5,333 (63.0)	28,665 (54.4)
Ae. albopictus males	5,786 (38.5)	2,321 (23.6)	1,781 (24.3)	2,835 (23.5)	2,391 (28.3)	15,144 (28.7)
Ae. atropalpus	0	1 (<0.1)	0	0	0	1 (<0.1)
Ae. japonicus japonicus	7 (<0.1)	199 (2.0)	68 (0.9)	45 (0.4)	31 (0.4)	350 (0.6)
Ae. sollicitans	0	1 (<0.1)	0	0	0	1 (<0.1)
Ae. stimulans	0	1 (<0.1)	0	0	0	1 (<0.1)
Ae. triseriatus	88 (0.6)	39 (0.4)	4 (<0.1)	28 (0.2)	9 (0.1)	168 (<0.1)
Ae. trivittatus	0	0	3 (<0.1)	0	0	3 (<0.1)
Ae. vexans	13 (0.1)	87 (0.9)	2 (<0.1)	19 (0.2)	2 (0.02)	123 (0.2)
Aedes spp.	0	0	2 (<0.1)	1 (<0.1)	1 (<0.1)	4 (<0.1)
Aedes spp. males	0	0	3 (<0.1)	2 (<0.1)	1 (<0.1)	6 (<0.1)
Anopheles barberi	0	4 (0.04)	0	0	0	4 (<0.1)
An. punctipennis	6 (<0.1)	49 (0.5)	1 (<0.1)	23 (0.2)	4 (0.05)	83 (1.2)
An. quadrimaculatus	12 (0.1)	34 (0.3)	16 (0.2)	17 (0.1)	43 (0.5)	122 (0.2)
Coquillettidia perturbans	0	0	1 (<0.1)	1 (<0.1)	0	2 (<0.1)
Culiseta melanura	0	1 (<0.1)	0	0	0	1 (<0.1)
Culex erraticus	30 (0.2)	29 (0.3)	17 (0.2)	20 (0.2)	94 (0.1)	190 (0.4)
Cx. pipiens pipiens	378 (2.5)	845 (8.6)	946 (12.9)	895 (7.4)	354 (4.2)	3,418 (6.5)
Cx. restuans	36 (0.2)	165 (1.7)	122 (1.7)	128 (1.1)	7 (0.1)	458 (0.9)
Cx. salinarius	1 (<0.1)	5 (0.1)	2 (<0.1)	1 (<0.1)	1 (<0.1)	10 (<0.1)
Cx. territans	0	8 (0.1)	4 (<0.1)	6 (<0.1)	2 (0.02)	20 (<0.1)
Culex spp.	326 (2.2)	69 (0.7)	67 (0.9)	1 (<0.1)	39 (0.5)	502 (0.95)
Culex spp. males	673 (4.5)	707 (7.2)	1,102 (15.0)	781 (6.5)	147 (1.7)	3,410 (6.8)
Orthopodomyia signifera	0	0	1 (<0.1)	1 (<0.1)	3 (0.04)	7 (<0.1)
Psorophora ciliata	1 (<0.1)	0	0	0	0	1 (<0.1)
Ps. columbiae	0	3 (<0.1)	0	1 (<0.1)	0	4 (<0.1)
Ps. ferox	0	1 (<0.1)	0	0	0	1 (<0.1)
Toxorhynchites rutilus septentrionalis	8 (0.1)	24 (0.2)	1 (<0.1)	8 (0.1)	1 (<0.1)	42 (<0.1)
Uranotaenia sapphirina	0	2 (<0.1)	0	0	0	2 (<0.1)
Total	15,048	9,818	7,338	12,044	8,463	52,713

that are designed to target females in different physiological stages have been demonstrated as an indication of trap placement near larval habitats. Study sites in Mercer County have extremely high numbers of containers in the residential backyards and alleyways (narrow passage between the parcels, which is very common in Trenton) (Bartlett-Healy et al. 2011, Unlu and Farajollahi 2012, Fonseca et al. 2013, Unlu et al. 2013). The probability of setting up a BGS trap within a close proximity to a container that holds *Ae. albopictus* larvae and pupae is high in Mercer County and may result in high male counts. Male mosquitoes were always used as crucial data during our "Area-wide Management of the Asian Tiger Mosquito" project. We used male and female collections while estimating action thresholds for ultra-low volume applications of adulticides because males are an important component of population dynamics and indicate species density within field habitats (Farajollahi et al. 2012). Because males display protandry, emerging 24–36 h before females, male catches also provide information on subsequent female emergence. The BGS trap is an effective surveillance tool not only for female *Ae. albopictus* but also for males. Data on male mosquitoes can also be used to optimize sterile insect techniques because the knowledge of survival, dispersal, and the longevity of genetically engineered male mosquitoes is important for the success of this control measure (Lacroix et al. 2009).

Trap counts for other species were well below those of *Ae. albopictus* during our surveillance. However, we still collected 23 other species, with *Culex* spp. as the 2nd most abundant group. *Culex p. pipiens* coexists with *Ae. albopictus* in container habitats within peridomestic environments of temperate North America; therefore, it is not unusual to collect the adults as the 2nd most common species in BGS traps (Unlu et al. 2013). Although the overall numbers may be low, *Cx. p. pipiens* collections can be increased by adding an octenol lure or CO_2, which would

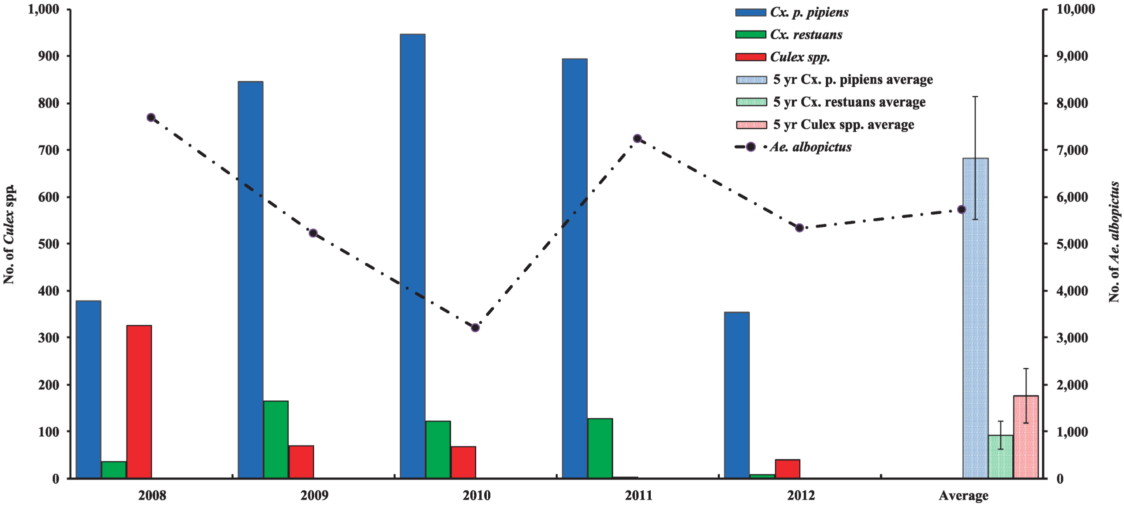

Fig. 1. Abundance of *Aedes albopictus*, *Culex pipiens pipiens*, *Cx. restuans*, and *Culex* spp. during 2008–12 in Mercer County, NJ. The average number of *Ae. albopictus* females and males were 5,851 ± 1,782.8 (mean ± SE) and 3,022 ± 710.8, respectively, for all 5 years.

allow surveillance programs to utilize this trap more efficiently (Irish et al. 2008). Surprisingly, even though *Ae. j. japonicus* coexists with *Ae. albopictus* within our study sites, adult collections were minimal during our investigations (Unlu et al. 2013). Anderson et al. (2012) were able to increase *Ae. j. japonicus* collections by using CO_2 and r-octenol in a Centers for Disease Control and Prevention miniature light trap. Further investigations are needed to determine if *Ae. j. japonicus* collections can be increased by using additional lures with BGS traps.

Culex mosquitoes are the principal vectors of West Nile virus (WNV) and St. Louis encephalitis virus in the USA. *Culex p. pipiens* has been incriminated as the primary vector for WNV in northeastern USA (Farajollahi et al. 2011) and *Cx. restuans* as the secondary vector in the transmission and maintenance of this virus (Andreadis et al. 2001). The BGS traps with the addition of the BG-Lure favor *Ae. albopictus* catch counts, but they also collect smaller numbers of *Culex* mosquitoes that can be used for disease surveillance. Increases in *Culex* spp. catch counts may also be enhanced through use of CO_2 or other attractive lures. Using this expensive trap for diseases surveillance would assist mosquito control agencies to justify the purchase and incorporation of these traps into existing programs as it provides information on mosquitoes of both nuisance and public health concerns.

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